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16. ABSTRACT

Probably no single material or group of materials has provoked so much discussion or controversy among engineers as the road building asphalts. Engineers and paving technologists have written reams of technical papers and engaged in perennial arguments among themselves and with the producers. Salesmen and the writers of advertising copy have not appreciably lessened the confusion. One will search in vain through the literature of the Asphalt Institute for an answer to the question "What is wrong with asphalt?

Seventeen years ago this September, a meeting of the justly famous Montana National Bituminous Conference was held in Glacier Park. Mr. Emil Skarin, connected with the Crown Paving Company in Edmonton, Canada, made an observation and expressed an opinion which has been echoed in one form or another by a great many engineers. Mr. Skarin stated that he had been building pavements since 1905 but that in recent years it seemed impossible to lay pavements without cracks, using the same methods and material, the only change being that in later years they had better equipment. Quoting Mr. Skarin, "We think that there has been a gradual lowering of the asphaltic quality in asphalt, but materials men are not ready to admit this, and the test of the asphalt have not shown any appreciable difference. So where is the trouble?" Mr. Skarin further stated, "In the early days asphalt was made from California crude oils. To a certain extent we are using them now as well.... We now probably use more mid-continental oil oil than we formerly used. Our methods of preparing mixes are very much the same.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

ASPHALT QUALITY CONTROLS

By

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Materials and Research Engineer
California Division of Highways

Presented at the 33rd Annual WASHO Conference
Sun Valley, Idaho
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By

F. N. Hveem*

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Quoting Mr. Skarin, "We think that there has been a gradual lowering of the asphaltic quality in asphalt, but materials men are not ready to admit this, and the tests of the asphalts have not shown any appreciable difference. So where is the trouble?" Mr. Skarin further stated, "In the early days asphalt was made from California crude oils. To a certain extent we are using them now as well .... We now probably use more mid-continental oil than we formerly used. Our methods of preparing mixes are very much the same. Only in the early days we had kettles and fires under them; now, of course, we use tanks with steam heated coils."(1) I believe that almost universally construction and maintenance engineers hold opinions similar to those expressed by Mr. Skarin. We have all heard many times - "Asphalt is not what it used to be." "All the life is gone out of it." "Asphalt is greasy." "It won't set up." "The mix dries up." And many more remarks along the same lines.

On the other side of the controversy are the manufacturers and vendors of asphaltic materials. With many exceptions of course their arguments frequently emphasize the following points.

1. Our material meets your specifications.
2. We have made no change in the method of manufacture.
3. The fault lies with the construction engineer who overheats the material in the plant.

"Anyway our asphalt is the equal of any other manufactured. And, finally, asphalt is a very cheap material and what do you want for five cents."

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In the middle are the materials engineers and the laboratory technicians who have not been too successful in proving that important changes either have or have not taken place in the quality of asphalts throughout the years. Thus we have the example of Mr. Skarin in 1937 protesting that asphalts were not as good as they were prior to 1910. We find "oldtimers" today whose experience began in the mid-thirties claiming that asphalts today are not as good as they were 20 years ago. However, the materials engineer is now in a position to state that virtually all of the asphalts used by the state highway departments today will meet the same specifications as were met 20 odd years ago.

But the engineers are no less dissatisfied and there appears to be a great deal of agreement on all sides that we need still closer control and if possible, asphaltic materials having better qualities. When we reach the question of what qualities are needed, the ideas become a little more vague and it seems that the one essential step is an analysis of the entire problem of building asphaltic roads in order to decide what are the important properties of asphalt. The first paper published in 1943 by the author and devoted to this subject(2) contained the following statement, "... any adhesive semiliquid material which can be made sufficiently fluid to permit mixing with the aggregate, which will adhere well to the stone in the presence of water, and which will not become brittle with age, will make a suitable binder for a road surface ...." Work has continued along the lines indicated in the 1943 report and after an additional 11 years I cannot add

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much to the statement. It still appears that the highway engineer need be concerned only with four properties of an asphalt which may be listed as

Consistency
Durability
Rate of Curing
Resistance to water action.

Following out this line of thought, what is needed therefore are test methods to measure these properties in a manner which parallels their operation in the pavement.

While the essentials are easily stated it has not proved to be an easy or simple matter to devise test methods that will clearly reflect the important properties. In the California laboratory, a special weathering machine, Fig. 1,[2,3] has been designed and constructed in order to subject samples to an atmospheric condition that is very similar to actual outdoor exposure. Temperatures in the specimen are maintained at not more than 140°F which represents no exaggeration of normal summer conditions. Lack of durability in an asphalt is principally manifested by rapid hardening and embrittlement. This quality is measured by spreading the asphalt in thin films over Ottawa sand grains, subjecting the coated grains to a definite period in the weathering machine, and then measuring brittleness by means of impact or abrasive action from free falling steel shot. The shot impinges on a compacted specimen of the asphalt coated sand and chips off or dislodges particles if the binder becomes hard or brittle.

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Figure 2 illustrates the manner in which the abrasive loss of a consolidated test specimen increases with the length of time in the weathering machine. It will be noted that there are marked differences in the rate of hardening of various asphaltic materials under atmospheric conditions that are in no way more severe than are encountered during outdoor exposure.

Figure 3 shows that it is quite evident that there is a wide difference in the response registered by paving asphalts, all of which have met the same current standard specification. Similar differences may be noted in the liquid asphalts. Figures 4 and 5 show a series of slow curing road oils selected to demonstrate that a wide variety of behavior or performance may develop from materials conforming to the same specifications and ostensibly of the same grade. While the foregoing examples are illustrations based on the behavior or changes in asphalts which develop under artificial weathering conditions, there is also evidence to show that asphalts from certain sources are more easily hardened during standard operations in the field. Figure 6 shows the original penetration of a group of asphalts compared to the penetration of the same asphalts after recovery from paving mixtures taken from various construction jobs. The three symbols identify asphalts from the three principal producing fields in California; namely, from the Los Angeles basin, from the Kern basin, and from the Santa Maria area. It will be noted that very few California asphalts in the past would retain more than 75 percent of the original penetration. It will also be noted that of the samples

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examined in this study none of the asphalt produced from certain crudes retained more than 50 percent of the original penetration after mixing in the pug mill.

Thus it would appear that there is a great deal of justification for some of the complaints originating with field engineers. There seems to be no doubt that asphalts meeting the same present day laboratory tests can and do show a considerable range or variety of behavior in the field. While we are on this subject it may be well to point out that the reputation of most construction materials depends almost entirely upon the opinion or reaction of the engineers or others whose chief interest lies in the actual construction. In other words if it will handle easily and lay down well any paving material will probably be regarded very favorably. The matter of long time performance and durability has much less influence upon current opinions. In any event, at the present time standard test procedures provide no satisfactory means of determining whether or not an asphalt will be durable, that is, whether it will retain the desirable properties of plasticity and adhesiveness and will resist hardening and embrittlement for a long period of time. The construction engineer cannot judge these properties by looking at the asphalt. The materials men today cannot tell very much that is worth while by means of current standard tests.

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The durability test mentioned above seems to give a fairly reliable concept of the relative durability under road conditions but unfortunately this particular test procedure would not be entirely practical for routine control because of the length of time required and in many cases the cost of the weathering machine would be a serious obstacle. Even though we do have the equipment in California, it is still considered impractical to apply this test as a method of routine control. As a practical matter it is necessary that our control tests be performed rapidly, and such tests should not require too expensive equipment and results should be reproducible.

Therefore, in order to make the first step towards establishing a better specification for asphalts, we were forced to fall back upon the commonly accepted test procedures, at least for the present, and attempt to secure the best asphalt possible by means of these controls. The apparatus for making these tests is on hand in most laboratories dealing with bituminous materials and we are simply trying to do the best we can with the available tools.

Of all the current tests, the one that appears to show the best correlation with durability under road conditions is the Flash test and our work appears to confirm the statements originally made by Lang and Thomas[4], Fig. 7. Figure 8 shows the relationship indicated by work in the California laboratory.

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At the present time virtually all of the asphaltic work in this state using paving grade asphalts is confined to three grades, 85-100, 120-150 and 200-300, although there are some signs of a trend toward the more frequent use of a harder grade, probably 60-70. In any event we have eliminated every other grade for the sake of greater simplicity and as a definite aid to the industry in reducing the number of grades they may be called upon to manufacture. Therefore, Fig. 9 lists the test limits proposed for the three most used grades. Figure 10 illustrates graphically the magnitude of some of the changes.

First and foremost are the requirements for the flash temperature, and these values have been established as high as seems feasible considering the products presently available in California. It will be noted that the flash is specified by means of the Pensky-Martens instrument as one of the laboratory operators from a major oil company brought to our attention the fact that silicones may cause a definite increase in the temperature reported by the Cleveland open cup flash tester. As agents containing silicones are rather widely used as anti-foaming agents, it appears that steps must be taken to eliminate erroneous results from this cause. One way around the difficulty is to use a flash tester that provides for stirring the sample. As the Pensky-Martens instrument provides this feature, this tester has been adopted in lieu of the Cleveland open cup. It should be noted however that a given asphalt will flash at a lower temperature in the Pensky-Martens instrument and therefore simply by

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changing the type of tester and maintaining the same specification we would have in effect raised the average flash point something over 20 degrees although there is no fixed relationship between the two test methods for all materials. In any event, the values shown represent a substantial elevation in the minimum flash temperatures and for many asphalts the change is greater than the numerical differences between the old and the new specification might indicate.

The loss on heating has been reduced to a permissible one percent, and the requirement for retention of penetration after loss on heating has been raised for all grades. A test new to California has been introduced in the form of the Penetration Ratio. This method is covered in AASHO designation T 49-49, and we have specified that the penetration at 39.2°F under a 200 gram weight for one minute shall be 25 percent of the standard penetration at 77°F. We would like to raise this requirement to a value of 30 or 35 but so far California producers could not meet such a requirement except with certain crudes.

As there is a possibility that these more rigid specifications may lead the manufacturers to try or adopt unforeseen expedients, it was felt that we should establish some limitation on the temperature that would be required at the paving plant to liquefy the asphalt to a suitable mixing viscosity. In other words, it has been generally established that present day asphalts can be mixed quite readily when reduced to a viscosity somewhere between 75 and 150 seconds. To safeguard against

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damage during heating, we are now somewhat arbitrarily specifying that an asphalt should reach this condition without requiring heating much beyond 275°F. For simplicity in testing therefore we have established 275°F and have specified a viscosity range for each grade. This is simply a precautionary specification which is set up with the sole idea of giving us some protection in the event that a manufacturer trying to meet the high flash and other requirements finds it possible to do so by additions which, while meeting other requirements, might also make it necessary to heat the asphalt to a point where damage would result in the pug mill. Solubility in CS_2 has been abandoned and the CCl_4 requirement is maintained simply to control the possibility of contamination or adulteration. It is not considered to be very important. The Heptane Xylene equivalent is also retained with the value lowered five points. The value of this test is of course somewhat debatable but it was developed for the purpose of controlling the addition of cracked asphalts and it seems to be pretty well established that the durability of cracked asphalts is generally poor. The Heptane Xylene equivalent is a simple method for controlling this feature.

In order of importance so far as durability is concerned, the flash control is first, the penetration ratio perhaps second, and the penetration after loss on heating probably third in importance. The other requirements shown are "just in case".

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This then is the present status of asphalt control tests in California. We are placing these new specifications in the special provisions for a number of contracts but they have not been incorporated in our revised standard specifications as I have not felt that the test methods shown are sufficiently reliable indicators of the properties in which we are interested. It is regarded by us as a stopgap attempt to eliminate the least durable asphalts and to confine our purchases to the better grades. As the manufacturers develop experience and demonstrate their ability to meet this specification it would seem proper and logical to tighten up on the test requirements still further, and even more important, to invent, develop or copy new and perhaps radically different test procedures to substitute for those now in use. This will be the next major activity so far as our laboratory is concerned.

The author wishes to acknowledge the contributions of Mr. Ernest Zube, Head of the Paving Section in this Laboratory, and especially of Mr. John Skog who has had direct charge of the investigative work which has established the relationships indicated herein. I would like also to mention the faithful work of Mr. James Kreiss who has conducted thousands of tests during the course of this research program. Finally, I would like to acknowledge the sincere interest, the spirit of cooperation and the substantial contributions made by representatives of the asphalt industry in California and of members of the Asphalt Institute in furthering the program to secure better asphalts for the construction of public highways.

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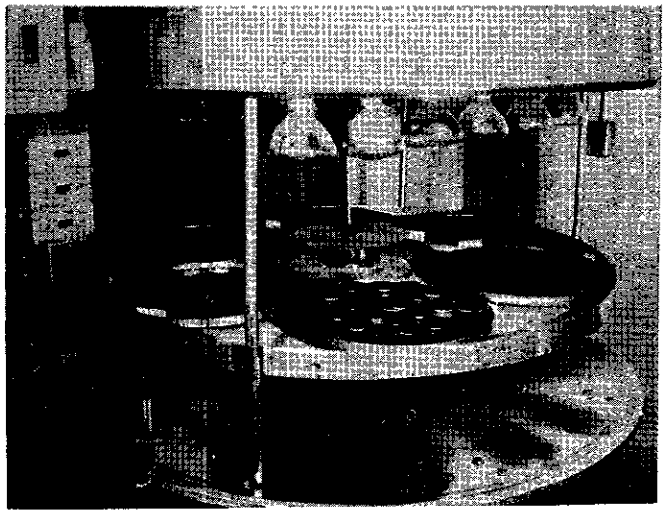

Interior View of Weathering Unit
Figure I

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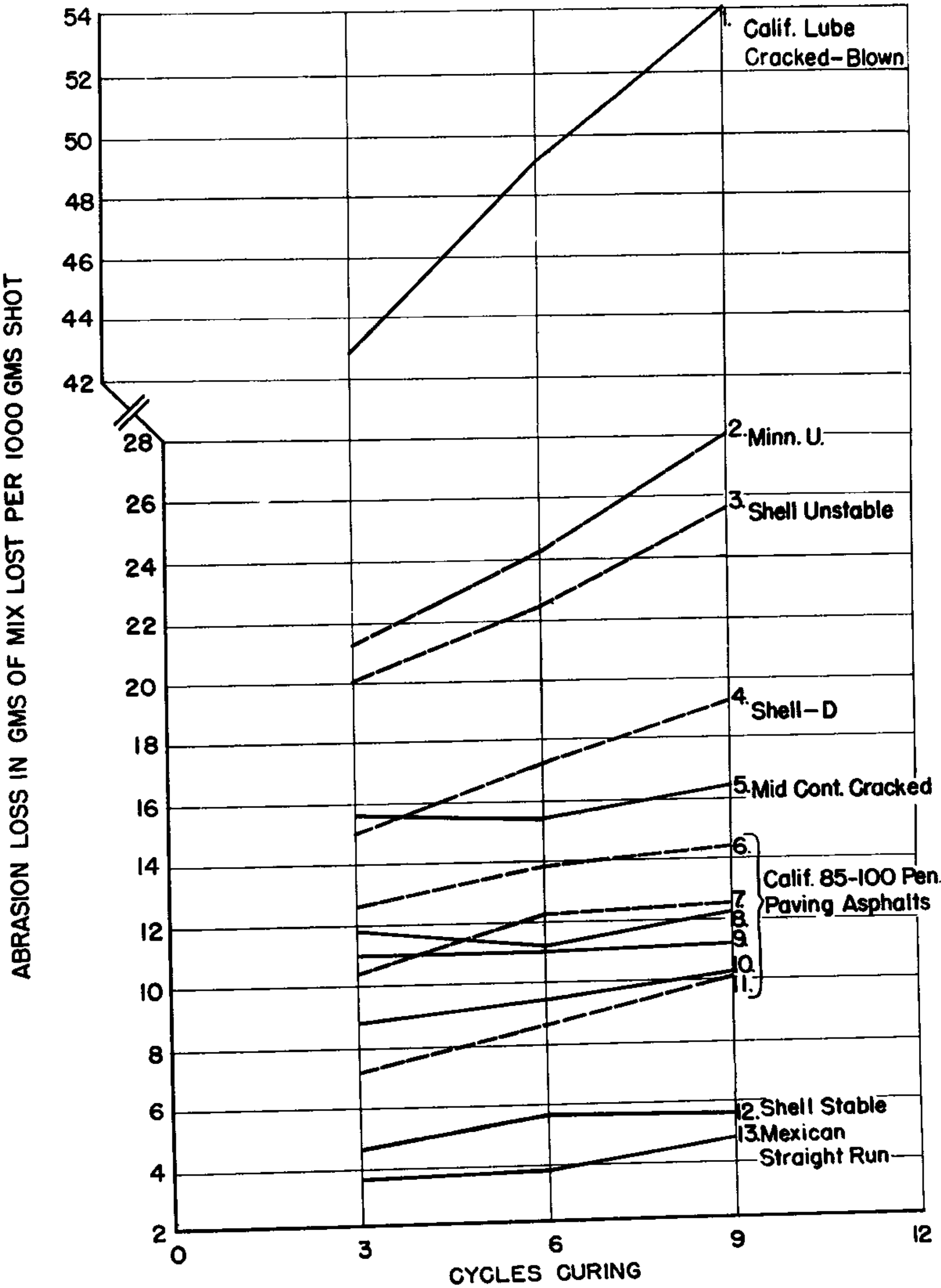

Figure 2

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ABRASION TEST CURVES FOR PAVING GRADE ASPHALTS

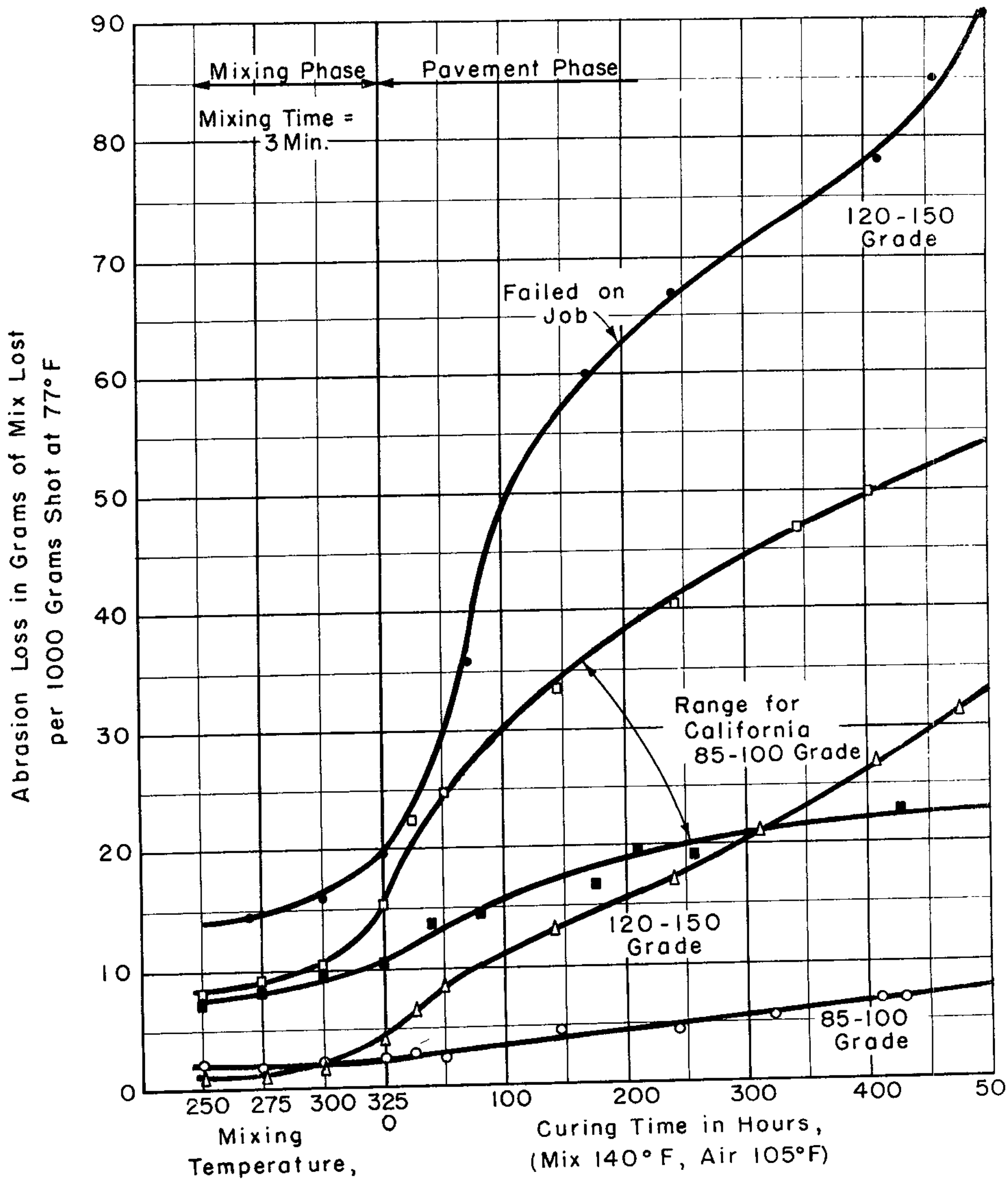

Figure 3

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CURING RATE CURVES FOR SPECIFICATION SLOW CURING, GRADE 2 LIQUID ASPHALTS

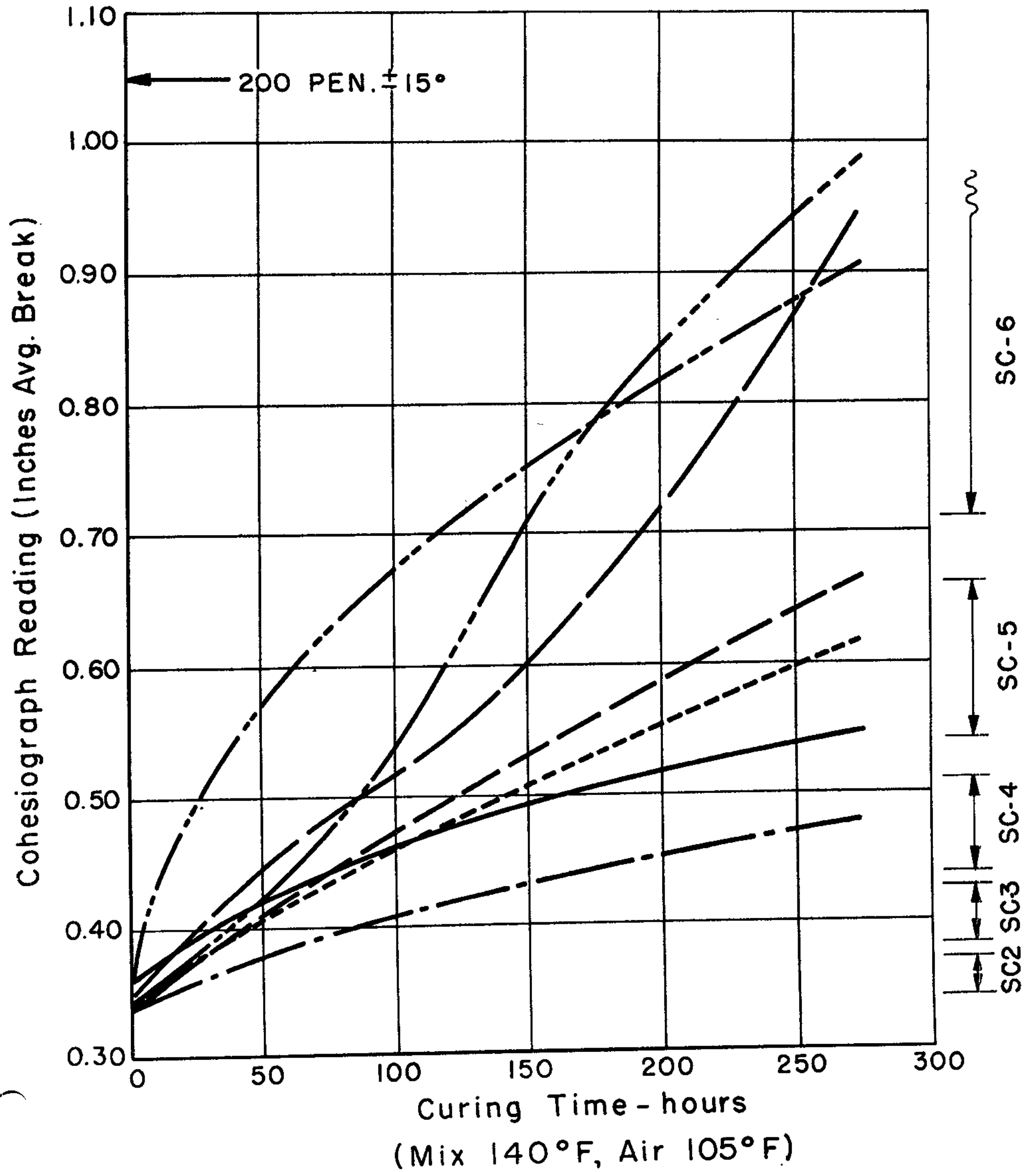

Figure 4

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CURING RATE CURVES FOR SPECIFICATION SLOW CURING, GRADE 4 LIQUID ASPHALTS

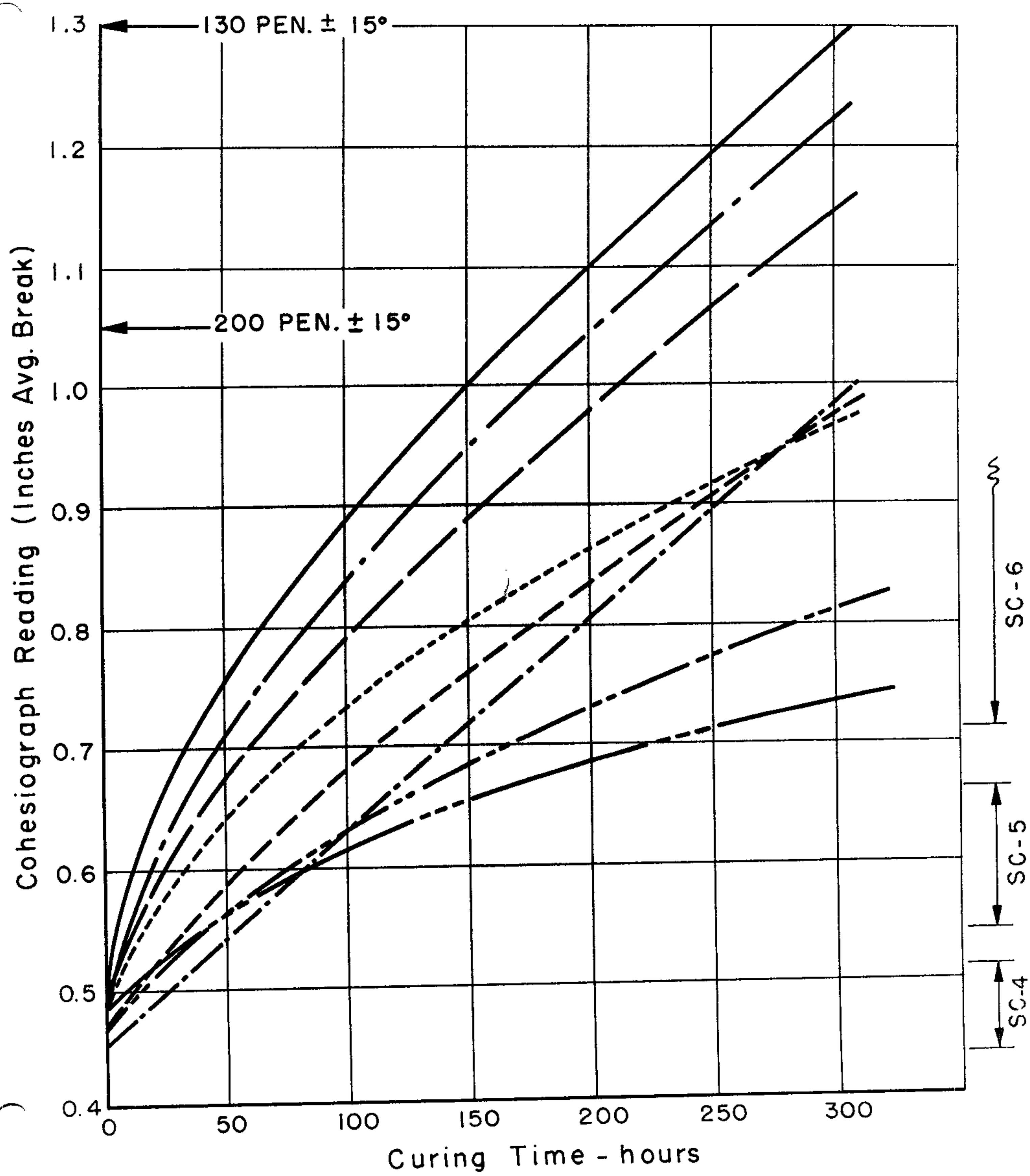

Figure 5

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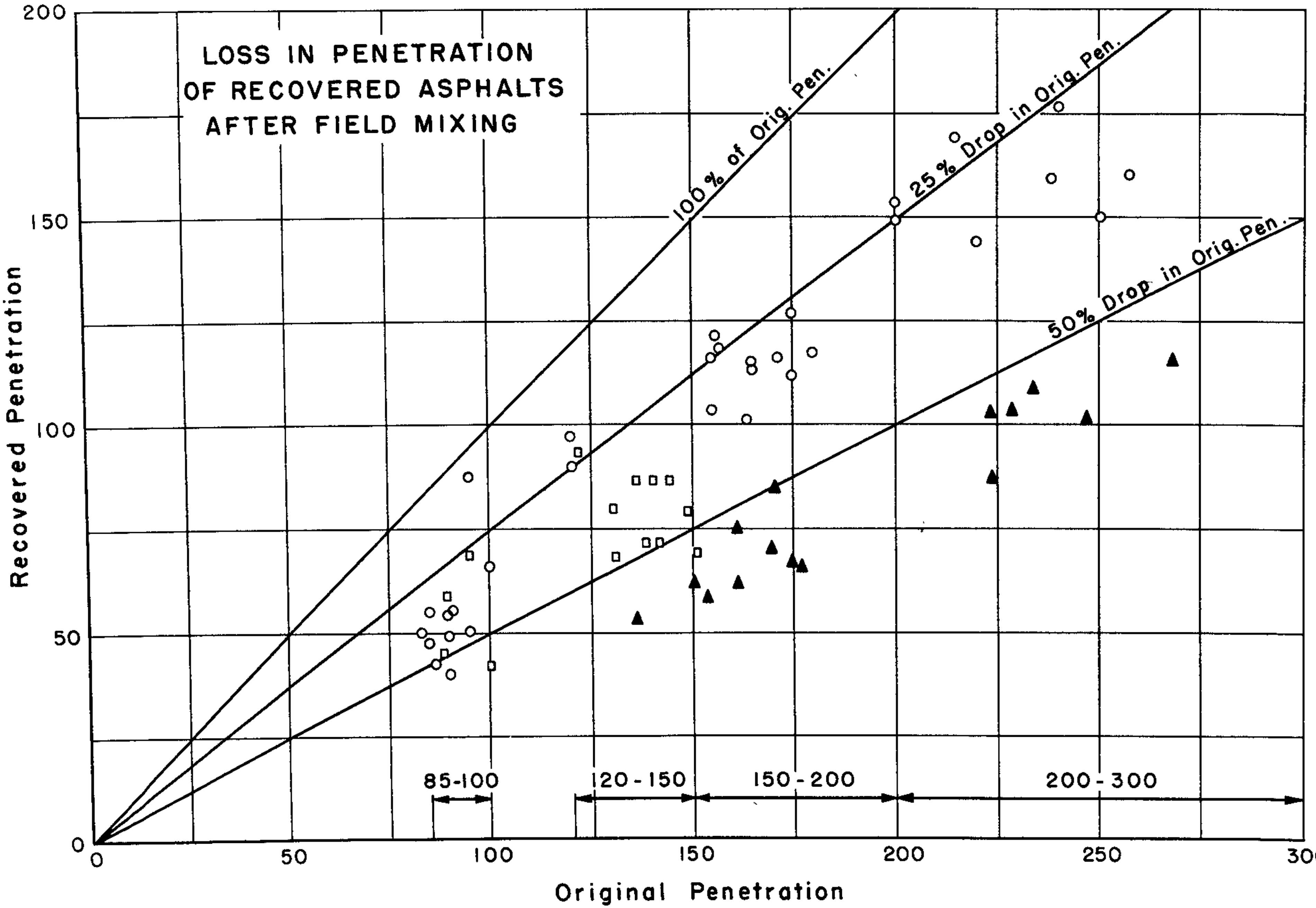

Figure 6

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RELATION OF CLEVELAND OPEN CUP FLASH
TO ABRASION LOSS
FOR 85-100 GRADE PAVING ASPHALTS
(From Lang & Thomas)

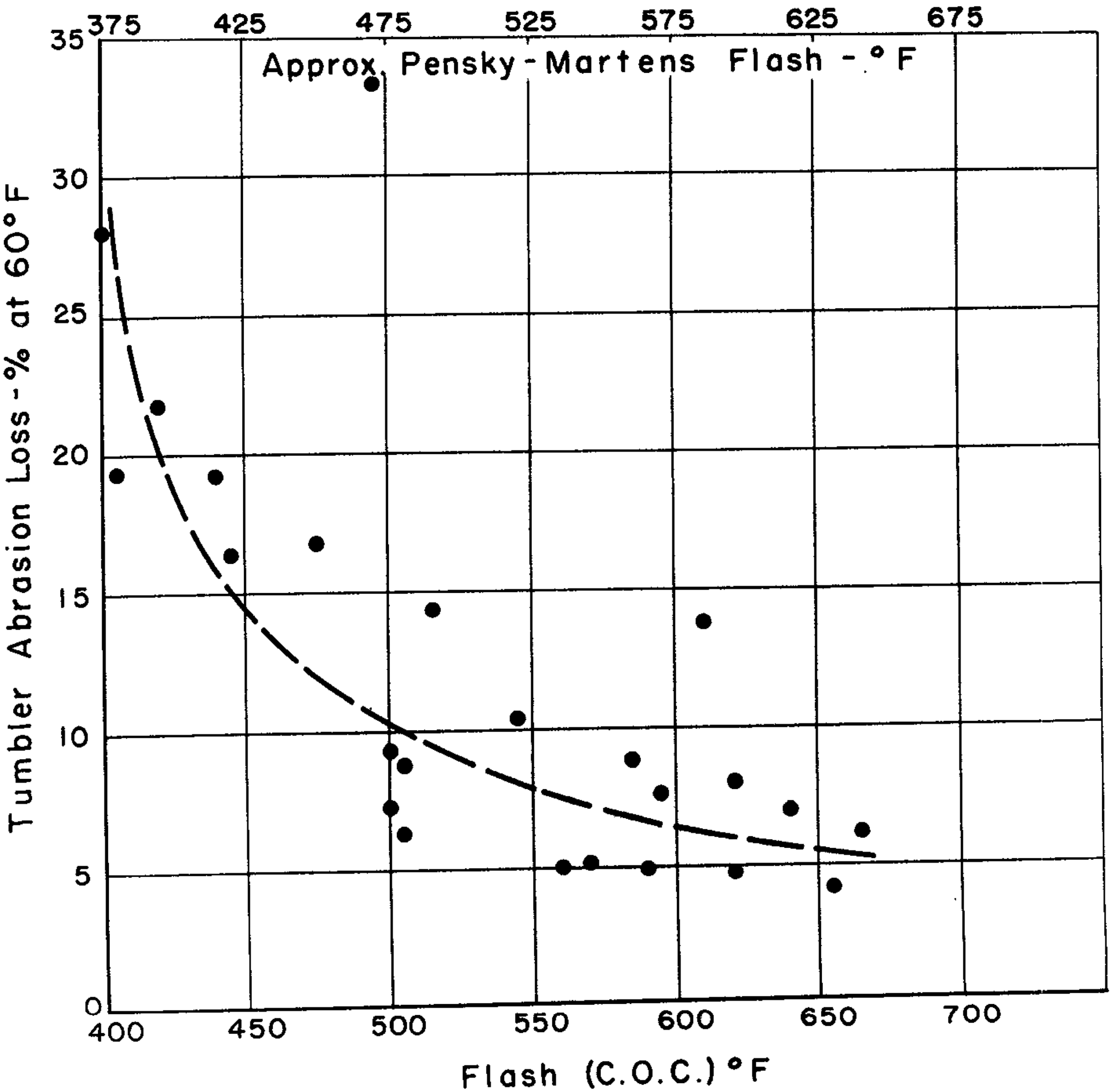

Figure 7

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RELATION OF CLEVELAND OPEN CUP FLASH TO ABRASION LOSS FOR CALIFORNIA 85-100 GRADE PAVING ASPHALTS

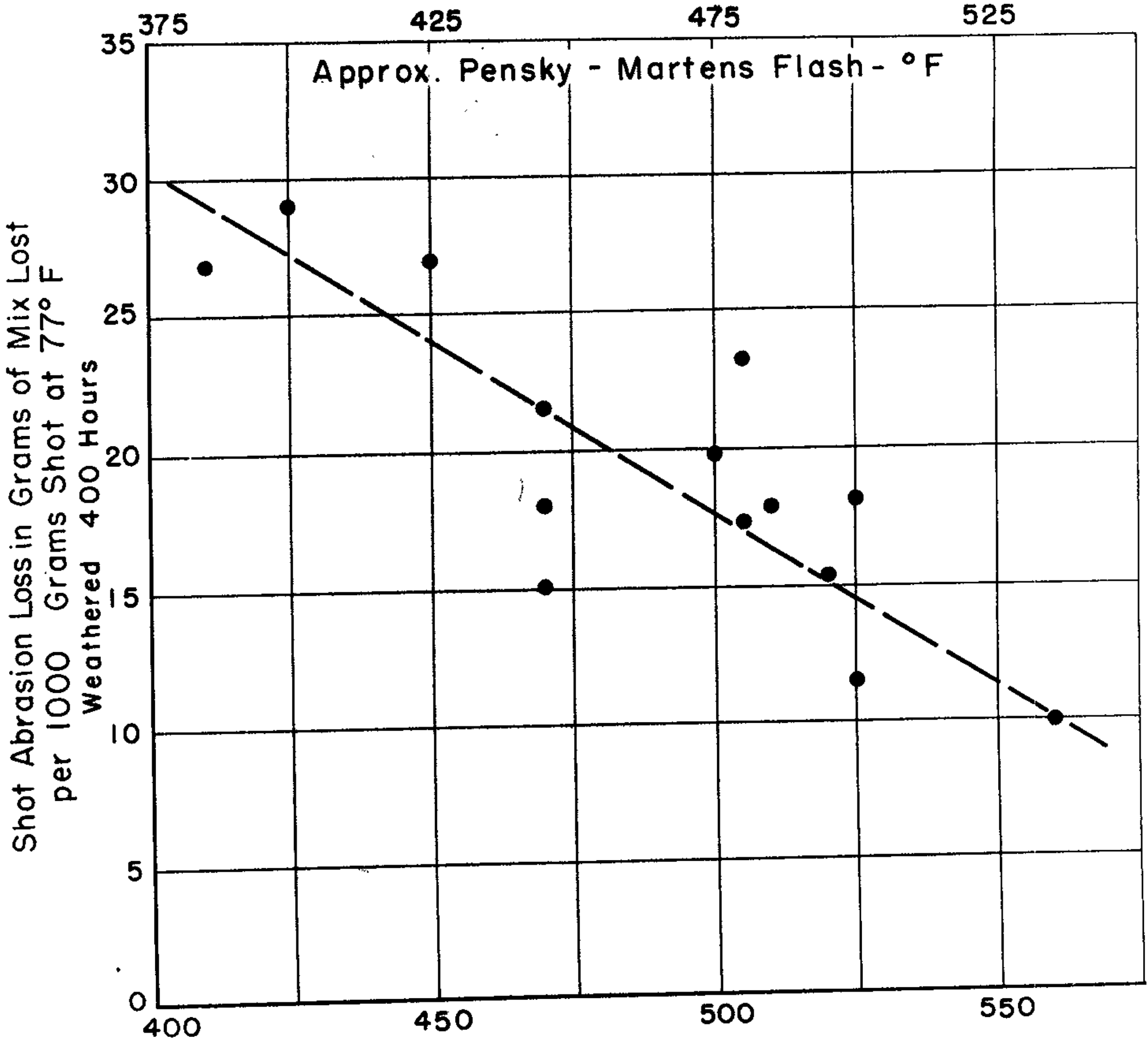

Figure 8

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1954 SPECIFICATIONS FOR PAVING GRADE ASPHALTS

SPECIFICATION DESIGNATION	AASHO TEST METHOD	GRADE		
		85-100	120-150	200-300
Flash Point P.M.C.T. °F. Min.	T 73-46	450	425	400
Penetration of original sample at 77°F.	T 49-49	85-100	120-150	200-300
Loss on heating 5 hours at 325° F % Max.	T 47-42	1	1	1
Penetration after loss on heating, % of original Min.	T 49-49	85	80	75
Penetration Ratio $\frac{\text{Pen. 39.2° F - 200 gm. - 1 Min.}}{\text{Pen. 77° F - 100 gm. - 5 Secs.}} \times 100$	T 49-49	25 Min.	25 Min.	25 Min.
Furol Viscosity at 275°F.	-	75-225	60-180	40-125
Solubility in CCl_4 % Min.	T 45-45	99	99	99
Xylene Equivalent % Max.	SEE SEC. 6 ART. G-14 CALIF. STDS.	30	30	30

Figure 9

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COMPARISON OF STANDARD & NEW PAVING GRADE ASPHALTS

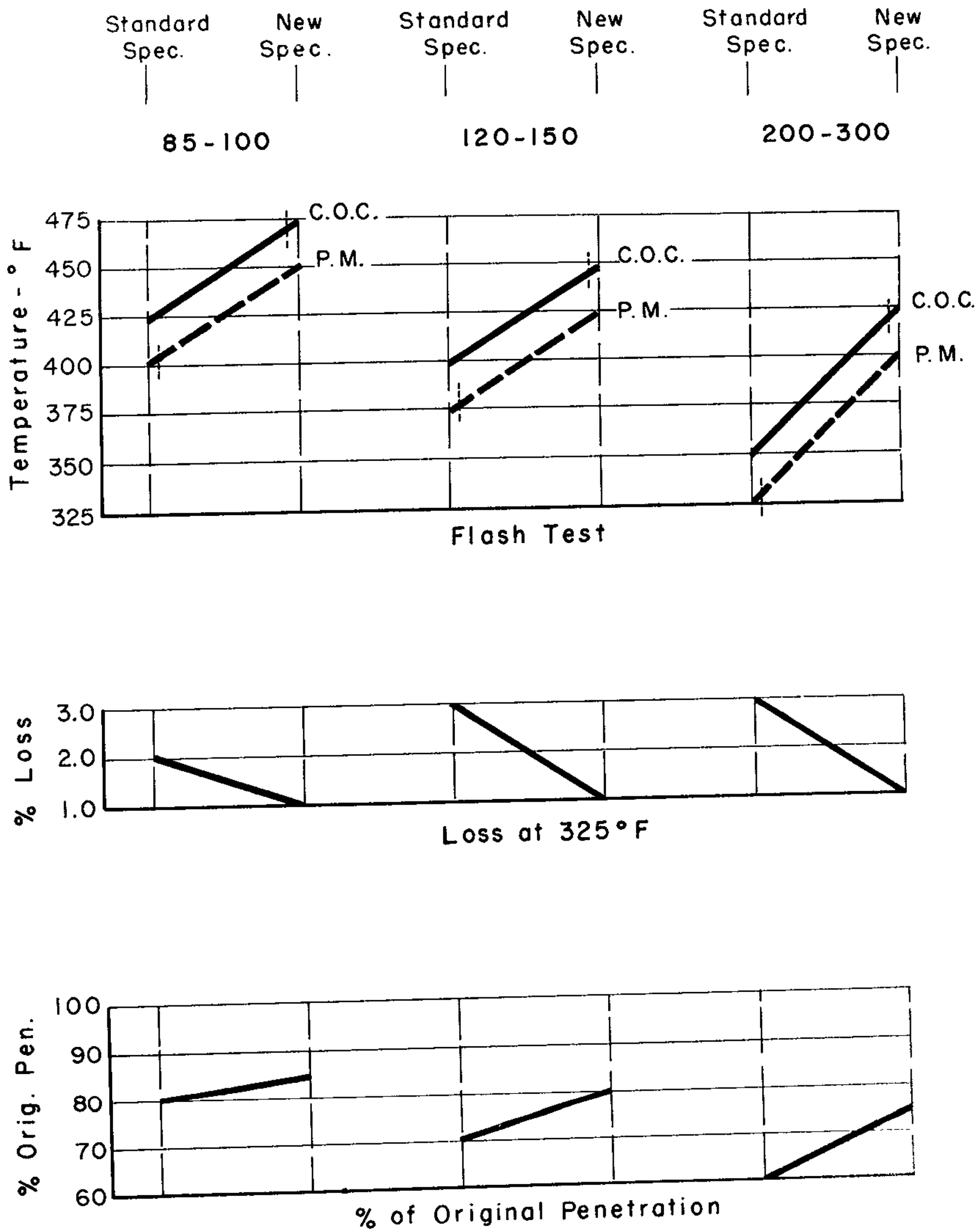

Figure 10

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